CTBT INTEGRATED VERIFICATION SYSTEM EVALUATION MODEL (IVSEM)

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ABSTRACT

The CTBT Integrated Verification System Evaluation Model (IVSEM) is being developed to provide a tool for evaluation of the relative utility of candidate monitoring system concepts, for exploring opportunities for synergy among monitoring technologies, and to help define needed technology thrusts. The goal is to develop an affordable, portable, and easy to use and understand model which is flexible enough and fast enough to allow for near real time evaluation of the relative effectiveness of a wide spectrum of user-definable monitoring and test configurations. The emphasis is on moderate fidelity modeling of the capabilities of an integrated monitoring system which combines multiple sensor types, as opposed to high fidelity monitoring of the individual sensor types (breadth versus depth). In its current form, the model includes seismic, hydroacoustic, infrasound, and radionuclide sensors and provides estimates of the detection effectiveness of a user-defined monitoring configuration against a user-defined test configuration (yield, location, altitude or depth and decoupling factor). Future efforts include incorporation of estimates of location and identification effectiveness plus validation of the model against more detailed single phenomenology models or experimental data. The model runs in near real-time on a PC or workstation platform.

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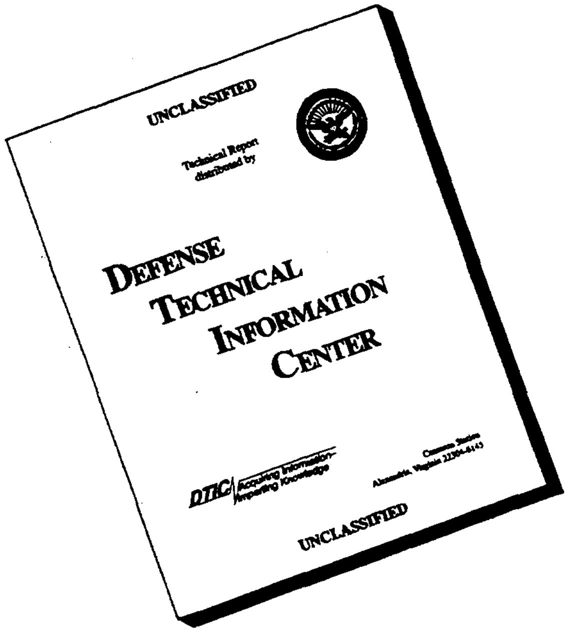

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OBJECTIVES:

The goal is to develop an affordable, portable, easy to use and understand model which is flexible enough and fast enough to allow for near real time evaluation of the relative effectiveness of a wide spectrum of user-definable CTBT monitoring and test configurations. It is envisioned that the model will be used to evaluate the relative utility of candidate monitoring system concepts, for exploring opportunities for synergy among monitoring technologies, and to help define needed technology research thrusts.

PRELIMINARY RESEARCH RESULTS:

Fig 1 depicts the major inputs to the model and the output products it provides. For each monitoring technology, the user can define the sensor locations, types, and noise levels and can enable or disable entire sensor types. This information can be input for immediate use or saved as "canned " files for later use. Previously generated input files can be edited in near real time. The user can also specify event parameters (test configurations) such as location, depth or altitude, and time, as well as other technical parameters such as coupling factors, required signal-to-noise ratios, fission fractions, etc. Finally, the user can define the criteria by which the effectiveness of the monitoring system is assessed. This definition can be in the form of specified criteria for what constitutes a "detected" event (e.g., four seismic responses, two seismics and two infrasounds, etc.) in which case the "system effectiveness" value assigned by the model is simply the probability of "detecting" the event. Alternately, the user can assign relative values of various combinations of station responses (e.g., two seismics are good, three seismics are better, three seismics and one infrasound are better yet, etc) in which case the "system effectiveness" value assigned by the model is a more qualitative, relative measure of goodness.

For a given set of input conditions, the model will calculate the probability of each station (sensor) responding and provides several output products. One of the output products is a map showing which stations responded. The model also provides a histogram representing the probability that a given number of each sensor type will respond. Using the user-defined scoring criteria, the system will calculate and plot a bar chart showing the "effectiveness" of each subsystem acting alone and of the combined system. Finally, the user can request that the system run the above calculations for each element of a grid of points across the globe (spaced at 7.5 degree intervals) and plot the combined results as a contour of system effective- ness. Single event calculations take a few seconds, the global contour calculations take about 10 minutes.

The heart of the model is that portion which takes the user defined inputs and operates on them to produce the output products. As shown in Fig 2, the model uses a generic set of processing steps, common to all monitoring technologies: First, based on the event specification, the model calculates the signal strength at the event in each of the relevant phenomenologies, then the model estimates the attenuation between the source and each station to arrive at a signal strength at each station. The signal is compared to the noise at each station to calculate the probability of response of each station, using the user specified criteria for response (e.g., signal to noise ratio). These individual station response probabilities are then operated on to generate the various displays and output products.

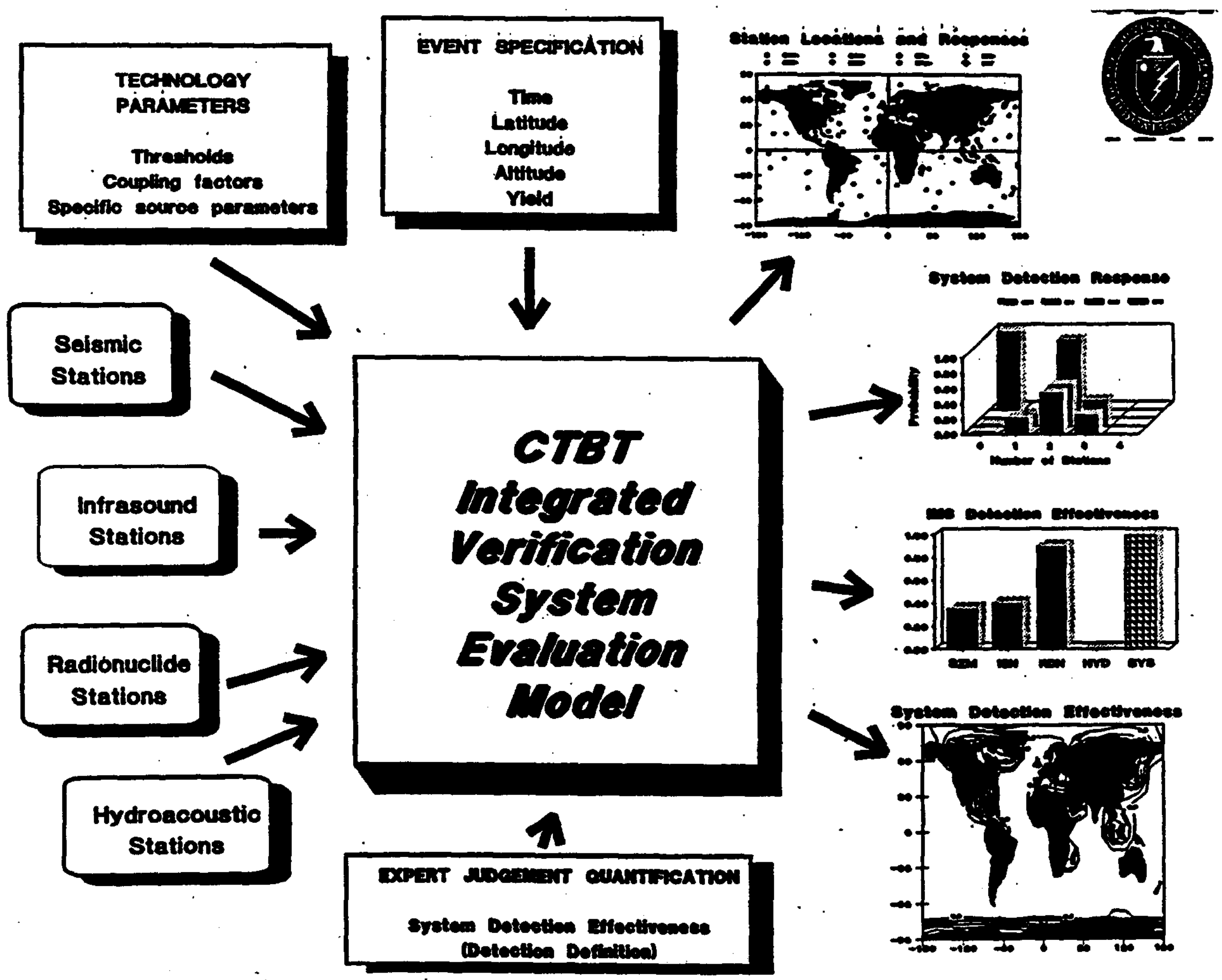
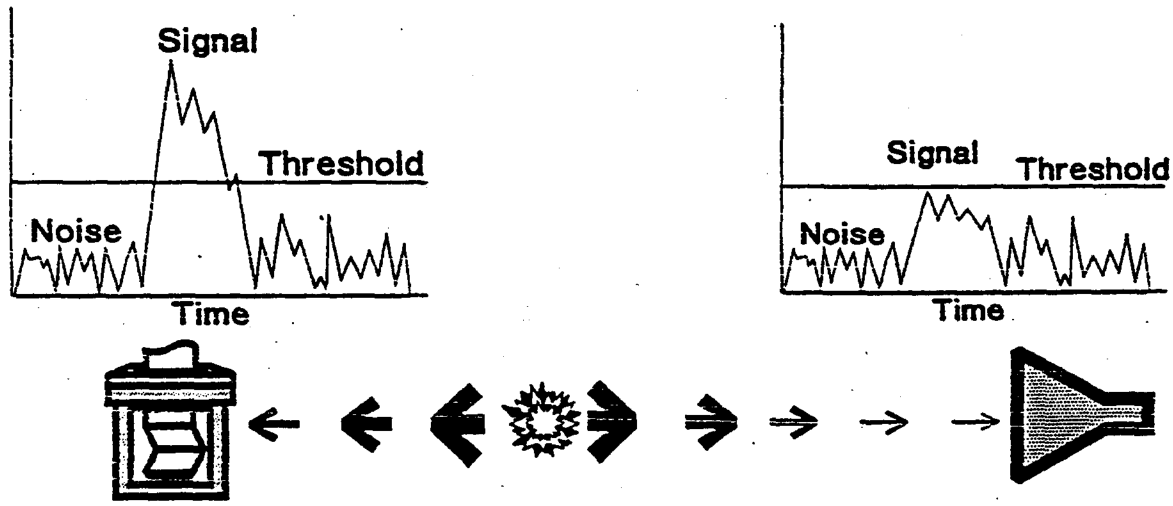


Figure 1

Subsystem Models Estimate the Probability that Individual Stations Respond to an Event



1. Signal Strength at Event
2. Attenuation and Propogation Effects
3. Signal Strength at Station
4. Noise and Signal Statistics
5. Probability that Station Responds

Figure 2

A conscious decision was made to emphasize breadth over depth in this model and to keep it simple, fast, and portable. Fig 3 summarizes the main simplifying assumptions made in association with these goals.

Simplifying Assumptions

What	Why	Effect
Seismic:		
P waves only (for detection)	Computation speed	Little on detection
Simple source and coupling	Facility, comp speed	Magnitude accuracy
No station corrections	Facility, no data	Small +- detection
Infrasound:		
No convergence zones	Facility, comp speed	Small +- signal
Hydroacoustic:		
Uniform bathymetry	Computation speed	+- signal, shadowing
Uniform sound velocity	Computation speed	Small +- signal
Radionuclide:		
Simple trajectory and cloud	Facility, comp speed	Not known presently
Xe-133g only (for detection)	Facility, comp speed	Little on detection

Figure 3

An obvious result of these simplifying assumptions is that the model does not provide the fidelity or capture all the nuances that individual phenomenology models can and this leaves open the question of the validity of the model. The proposed validation approach is not to try to defend the algorithms in terms of their ability to accurately model all the physics on a first-principles basis, but rather to benchmark the model against existing, generally accepted single phenomenology models and experimental data where available. Fig 4 summarizes the planned validation approach for each of the four subsystems.

CTBT Integrated Verification System Evaluation Model Validation

	Comparison to more Comprehensive Models	Comparison to Experimental data
Seismic	Preliminary comparison of detection probability vs. range and location accuracy with NETSIM	Defer to comparison of NETSIM results with experimental data
Infrasound	Pursuing comparison to LANL Normal Modes code	Preliminary comparison to NTS shot amplitudes at St. George & Bishop for different months
Radionuclide	Results presently being compared to PSR HYSPLIT results	Defer to PSR's comparison of HYSPLIT results to experimental data
Hydroacoustic	Will pursue comparison with Adiabatic Parabolic Equation Code at NRL and LLNL/NRL code when available	Will pursue comparison to Heard Island and other test data

Figure 4

Preliminary validation results for the seismic portion of the model are shown in Fig 5 which compares the probability of detection versus range for IVSEM versus the more detailed NETSIM model for a 1kt, fully coupled event using low noise, three axis stations.

Seismic Detection Probabilities

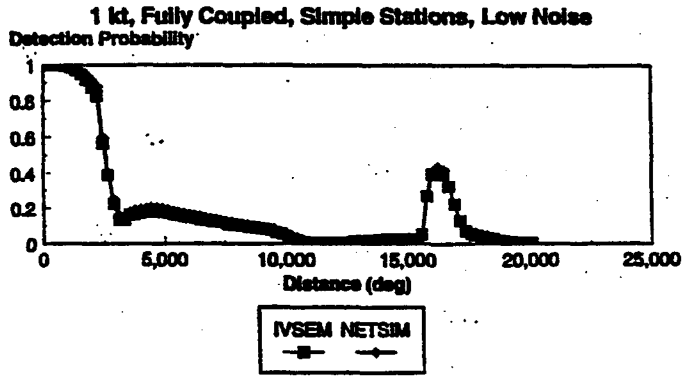


Figure 5

There is as yet no well accepted, comprehensive single phenomenology model for infrasound, so the IVSEM model results have been compared against a set of experimental data as shown in Fig 6. There is a wide spread in the experimental data reflecting the effect of large wind variations. The model does however match the mean conditions fairly well.

Infrasound Model Results
Station due West of Event

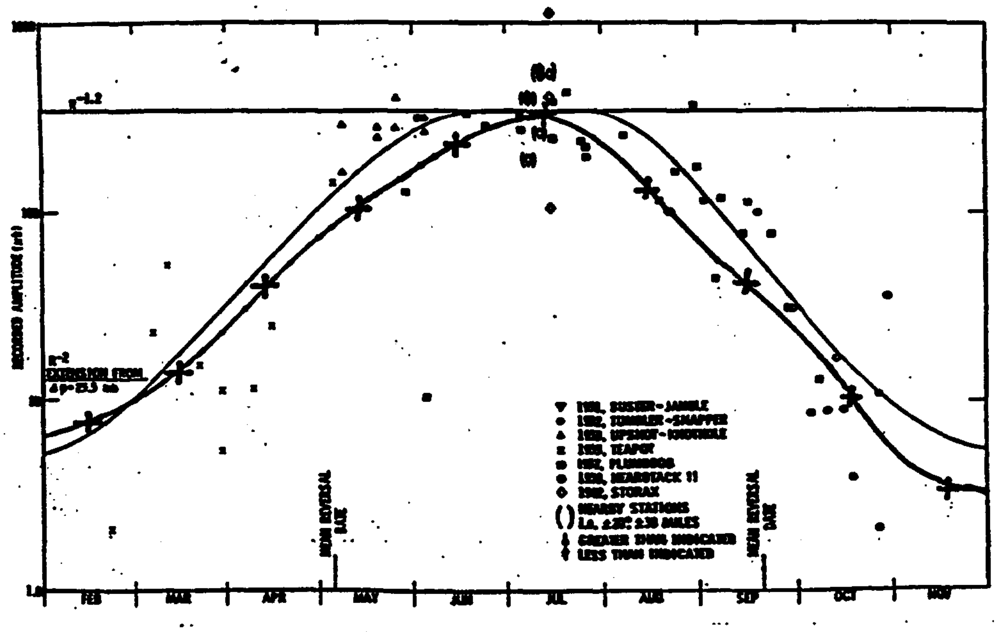


Figure 6

RECOMMENDATIONS AND FUTURE PLANS:

Fig 7 summarizes the schedule for planned model development efforts, which include addition of location and identification capability predictions, plus model validation.

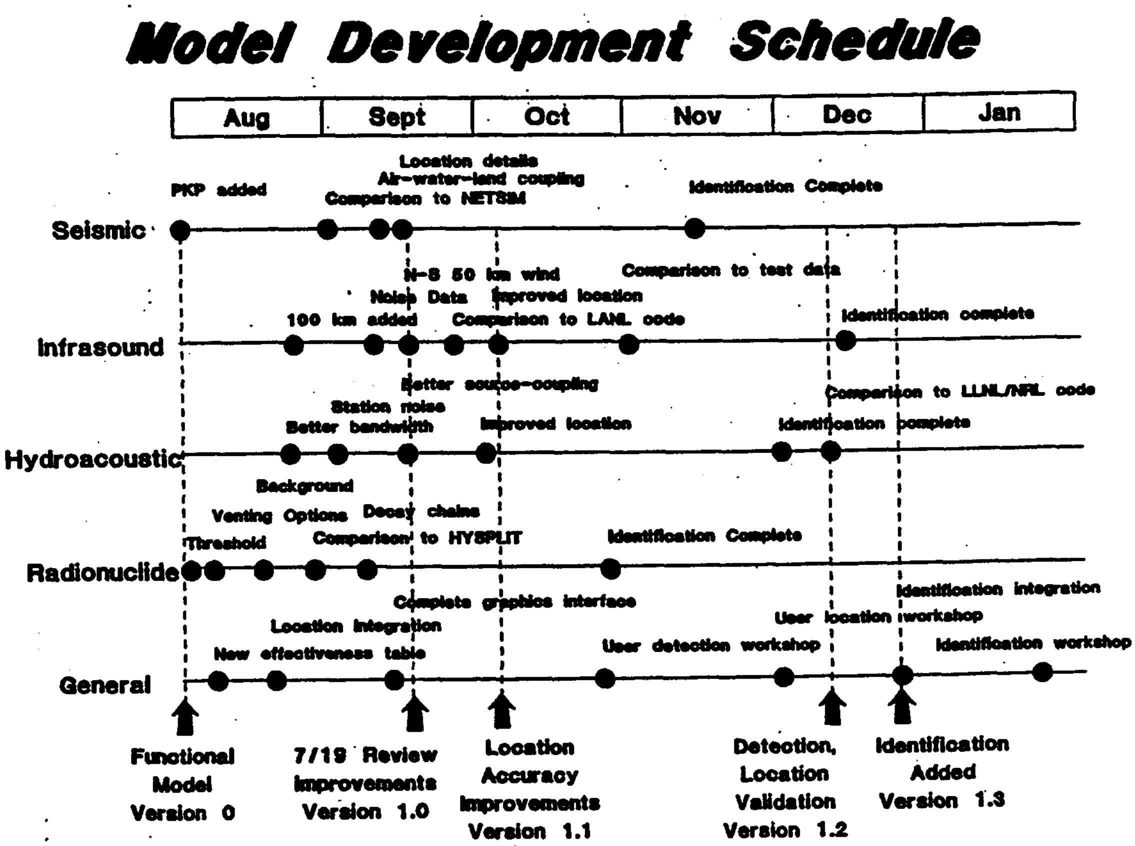


Figure 7